PATENT SPECIFICATION

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(31) Convention Application No. 7318501 (32) Filed 22 May 1973 in
(33) France (FR)
(44) Complete Specification published 22 Sept. 1976
(51) INT CL^2 G01S 9/44
(52) Index at acceptance
H4D 265 271 362 396

(19)

(54) AN INTRUSION DETECTOR

(71) I MAURICE TACUSSEL, a French Citizen, of 105 bis rue due Point du Jour, 92100 Boulogne-Billancourt, France, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an intrusion detector employing electromagnetic radiation and, more particularly, to such a detector operating on the principle of the Doppler effect.

Intrusion detectors which provide permanent supervision of premises to be guarded are already known. Such detectors trigger an alarm device, for example, a bell or siren, as soon as an intruder enters the field of radiation of the antenna of the device.

Known devices of this type generally operate at relatively low frequencies (400—900 MHz) although the most recent devices operate at ultra-high frequencies of 10,000 MHz and above.

ERRATUM

SPECIFICATION No. 1,450,236

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THE PATENT OFFICE
25th February, 1977

... cannot generally provide sufficient sharpness of directivity in its beam because, with the frequencies employed, antennae with the correct directional efficiency would require to be of unduly large dimensions.

In the case of systems of the second type operating at ultra-high frequencies, directional antennae of reduced dimensions can be employed but such antennae, together with the associated ultra-high frequency circuits, are costly to produce. Moreover, the energy efficiency of such systems is low, and the current consumption is high, which is a disadvantage in self-contained systems.

It is possible to mitigate such disadvantages by combining a highly directional antenna, which is inexpensive and compact, with the circuits of the system.

According to the present invention there is provided an intrusion detector having a main unit and a warning device the main unit comprising a transmitter, a receiver, an antenna and an amplifier for passing a warning signal to the warning device, a signal being emitted by the transmitter and after being modified by the Doppler effect created by the movement ...

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In accordance with one particular feature of the invention the detector may also include an auxiliary receiver-antenna unit pass-

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The present invention relates to an intrusion detector employing electromagnetic radiation and, more particularly, to such a detector operating on the principle of the Doppler effect.

Intrusion detectors which provide permanent supervision of premises to be guarded are already known. Such detectors trigger an alarm device, for example, a bell or siren, as soon as an intruder enters the field of radiation of the antenna of the device.

Known devices of this type generally operate at relatively low frequencies (400—900 MHz) although the most recent devices operate at ultra-high frequencies of 10,000 MHz and above.

Such devices must naturally be very sensitive, which in turn increases the risk of false alarms, that is to say, that the device may in certain cases set off the alarm system inopportunely even when there has been no intrusion. Such false alarms are generally due to electrical interference from domestic or industrial electrical equipment. In spite of precautions to attenuate the influence of such electrical interference, known systems, especially of the first type, suffer this defect which represent a serious disadvantage for the owner.

The present invention does not possess this disadvantage so that all risk of inopportune release is obviated.

A further disadvantage of known systems is due to the precise limitations required of the effective field of radiation of the device, that is to say, its field of protection.

In known systems of the first type the antennae cannot generally provide sufficient sharpness of directivity in its beam because, with the frequencies employed, antennae with the correct directional efficiency would require to be of unduly large dimensions.

In the case of systems of the second type operating at ultra-high frequencies, directional antennae of reduced dimensions can be employed but such antennae, together with the associated ultra-high frequency circuits, are costly to produce. Moreover, the energy efficiency of such systems is low, and the current consumption is high, which is a disadvantage in self-contained systems.

It is possible to mitigate such disadvantages by combining a highly directional antenna, which is inexpensive and compact, with the circuits of the system.

According to the present invention there is provided an intrusion detector having a main unit and a warning device the main unit comprising a transmitter, a receiver, an antenna and an amplifier for passing a warning signal to the warning device, a signal being emitted by the transmitter and after being modified by the Doppler effect created by the movement of an intruder within the field of the antenna being received by the receiver thereby to produce the warning signal, and including an inhibiting circuit connected between the said main unit and the warning device; and an auxiliary amplifier for receiving and amplifying ambient interference signals and connected to one of the inputs of said inhibiting circuit so that the inhibiting circuit disconnects the main unit from the warning device in response to a signal issuing from said auxiliary amplifier.

In accordance with one embodiment of the invention the inhibiting circuit is an electronic gate, one input of which receives the signals provided by the main circuit and the other input receives only the parasitic signals provided by the auxiliary circuit. As a result of this arrangement the gate prevents release of the alarm when the system is influenced by an intense field of ambient electrical interference, thus eliminating all possibility of false alarms.

In accordance with one particular feature of the invention the detector may also include an auxiliary receiver-antenna unit pass-

ing a reception signal to the aforementioned auxiliary amplifier only in response to a signal transmitted from a remote-controlled portable alarm inhibiting transmitter which is tuned to the same frequency as the auxiliary unit in order to synchronise said intrusion detector with the portable transmitter.

The portable transmitter is employed by the owner of the intrusion detector as a remote control which inhibits the detector without setting off the alarm, only the frequency of the portable transmitter synchronised with the detector being capable of neutralising the detector.

The system according to the invention operates preferably at frequencies of 1,000—5,000 MHz, i.e. frequencies lying between those of the two known types referred to above.

This system is only recently possible as a result of the progress made in transistors which can now operate at ultra-high frequencies.

Operating for example at frequencies be-between 2,000 MHz and 4,000 MHz, it is possible, on the one hand, to produce transistor-type transmitter-receivers, and on the other hand to utilise the microstrip technique for high frequency circuits. This latter is particularly well adapted to mass-production by photoetching on dielectric substrates.

The conception of intrusion detectors operating in this frequency band has not been exploited because the high frequency circuits and the antennae are generally regarded as presenting problems in manufacture.

The intrusion detector in accordance with the invention can operate for example in the 2400—2500 MHz frequency band. It detects the Doppler effect created by a person moving within its field.

The antenna of the main unit described above is a directional antenna covering a large area in the horizontal plane whilst having a sufficiently narrow beam in the vertical plane. The narrow beam in the vertical plane enables it to eliminate false alarms where the system is employed in an old building of several storeys, whose ceiling and floors, which are generally of wood, are partially transparent to electromagnetic radiation.

The effective range may be adapted to the surface area of the premises to be protected.

A directional antenna which is particularly suitable for employment in the intrusion detector of the present invention is described in British Patent Application No. 19514/74 filed on 3rd May, 1974 in the name of the same inventor and under the title "Directional Antenna".

In particular, such an antenna produced by photoetching on a dielectric substrate may be employed following microstrip techniques for forming the high frequency circuits of the intrusion detector, certain elements of which at least are thus combined directly with the antenna.

The detector according to the invention may be entirely self-contained by employing an accumulator or electric battery and an alarm device (siren or bell) incorporated therewith.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a circuit diagram of the main elements of the intrusion detector;

Fig. 2 is a circuit diagram of the ultra-high frequency circuits of the detector;

Fig. 3 illustrates an embodiment of the ultra-high frequency circuits employing microstrip technique on the insulating substrate of the antenna; and

Fig. 4 is a front view and part-rear view of the antenna.

The intrusion detector comprises the following elements illustrated in Fig. 1:

(1) A directional antenna 2 employed for transmission and reception of ultra-high frequency signals;

(2) An ultra-high frequency transistor oscillator 4 employed as transmitter and also as receiver since it can operate as a homodyne detector;

(3) A low-frequency or main circuit amplifier 6 which increases the level of beat signals after detection;

(4) A low-frequency auxiliary amplifier 8 serving not only as a detector of electrical interference produced by domestic or industrial electrical equipment, but also as an amplifier of a remote-control stop signal;

(5) A gate 10 controlled by the auxiliary amplifier which prevents triggering of the alarm when the system is influenced by an intense field of electrical interference or when the remote-control stop device is employed;

(6) A time switch 12 in the form of a monostable circuit for the purpose of continuing operation of the alarm for a predetermined period of time;

(7) A direct current amplifier 14 supplying an alarm siren 16 and controlled by the time switch;

(8) A superheterodyne receiver 18 operating in the 27 MHz band, including a quartz crystal oscillator and a built-in antenna 20;

(9) A voltage supply system 22 for the various circuits of the system, and

(10) A pocket transmitter 24 employed by the owner of the system to neutralise its activity when he approaches it.

The ultra-high frequency oscillator 4 and its manner of operation will now be described in detail with reference to Figs. 2 and 3.

The oscillator operates both as a transmitter and as a homodyne receiver. As trans-

mitter, it produces an ultra-high frequency signal of frequency f_o beamed by the antenna.

When a moving obstacle influences the field of the device, a fraction of the energy emitted is affected by the Doppler effect and returns to the oscillator by way of the antenna. The frequency of this signal is $f_o \pm f_d$ according to the direction of movement of the obstacle. f_d is the Doppler frequency as a function of f_o and of the speed of displacement.

An oscillator is generally regarded as a negative non-linear conductance. By way of this conductance, the signal of the oscillator at f_o and that reflected by the obstacle produce a beat signal

$$f_o-(f_o \pm f_d)=f_d,$$

corresponding to the Doppler frequency.

With $f_o=2450$ MHz, for example, f_d is approximately 5 Hz per km/h.

This low-frequency beat signal is then amplified and employed to trigger the alarm device.

The oscillator employs as a non-linear element a transistor Q_1 (Figs. 2 and 3) whose cut-out frequency must necessarily be greater than the oscillation frequency f_o.

Resistances R_1, R_2, R_3 fix the bias conditions of the transistor in order to release oscillations when under voltage.

The ultra-high frequency circuits comprise impedances Z_1, Z_2, Z_3. These are decoupled from the bias resistors by way of capacitors C_2, C_3, C_4.

In the receiving function, the beat product of f_d produced in the base-emitter junction circulates by way of the capacitor C_1. It is amplified by the transistor and appears at the terminals of R_4.

In a preferred embodiment of the detector, ultra-high frequency circuits Z_1, Z_2, Z_3 and the decoupling elements C_2, C_3, C_4 are produced by microstrip technique (strip lines on dielectric substrate) of which an example will now be described with reference to Fig. 3.

Here, Z_1 consists of an open line of characteristic impedance 50 ohms and of length 0.37 λ_1, λ_1 being the wave length in the dielectric medium.

Z_3 is formed by a line of 70 ohms impedance and of length 0.24 λ_1.

Z_2 is represented by the resistance of the antenna which, in this case, is 50 ohms. This resistance is connected to the collector of the transistor through a line Z_0 of characteristic impedance 50 ohms.

Voltages are applied to the transistor through band-stop filters tuned to the frequency f_o. These latter, for base and collector, are provided by a series line L with characteristic impedance 100 ohms and of length $\frac{1}{4}\lambda_1$ on which are placed in parallel two open lines C of 25 ohms impedance and of length $\frac{1}{4}\lambda_1$. The transmitter is formed by two open lines C of the same characteristics as the foregoing, placed in parallel on Z_3.

The transistor Q_1 may be selected from low-power transistors capable of operating up to 5000 MHz.

As will be seen hereinafter, the oscillator is preferably formed on the same substrate as the antenna to form a homogeneous unit which is simple to fabricate and may be employed in various other applications.

The main circuit amplifier 6 and auxiliary amplifier 8 will now be described (Fig. 1).

The purpose of the main circuit amplifier 6 is to amplify Doppler signals detected by the oscillator 4. It is formed with the aid of operational amplifiers which, due to their rejection of the common mode, are relatively insensitive to variations in supply voltage and to electrical interference.

The auxiliary amplifier 18 is employed mainly as a detector of electrical interference. Indeed, in certain cases where the system is employed, it is exposed to an intense field of interference emanating from domestic or industrial electrical equipment. Even although the main amplifier 6 has an excellent immunity to such interference, it might however be induced to pick up some such signals and trigger the alarm.

When the auxiliary amplifier 8 is exposed to the same field of interference as the main amplifier 6, owing to its greater gain and to an electronic gate 10 common to both circuits, it blocks the interference present in the main circuit. The auxiliary amplifier 8 comprises a low-frequency operational amplifier the output of which is connected to each of the inputs of a direct current operational amplifier through a respective one of a pair of opposed diodes. The auxiliary amplifier 8 transmits to the electronic gate 10 the signals from the remote-control receiver which are intended to render the system inoperative.

The electronic gate 10 which provides the inhibiting circuit is in the form of an operational amplifier.

The signals from the main circuit pass to the positive input and those from the auxiliary circuit to the negative input.

By the choice of bias voltages a signal (parasitic or remote-control) present in the auxiliary circuit closes the gate and the signal from the main circuit is not transmitted.

The time switch 12 is a monostable circuit whose function is to release the alarm device. In the "on" position, the switch 12 is in a condition such that the alarm device is inactive. When a signal is transmitted through the electronic gate 10, the monostable circuit is tripped and releases the alarm control. The time constant is regulated so that it remains in this condition for approxi-

mately 90 seconds. It then returns to its original condition in approximately 15 seconds.

This time constant is also employed to inhibit the alarm when the system is placed under voltage.

The monostable circuit consists of an operational amplifier arranged in a particular configuration of a Schmitt trigger. The direct current amplifier 14 is controlled by the monostable circuit 12, and is employed for placing the alarm siren under voltage. This amplifier comprises two transistors in Darlington connection.

In accordance with one embodiment of the invention, the detector may comprise an alarm-release timing system by means of which the owner of the device may approach it during a period of time not exceeding the predetermined time lag when he is setting or switching off the system.

In accordance with a preferred embodiment, the intrusion detector system does not comprise an alarm-release time mechanism because a time-delay setting might give the intruder time to act and then to escape before the alarm is released. The system therefore detects an intruder immediately he enters its field of supervision.

In order to allow the owner of the device to approach it while it is operating, a remote-control device for rendering the alarm inoperative is incorporated in the system and is now described in detail.

The remote-control stop device comprises a pocket transmitter operating on a permitted frequency in the 27 MHz band, and a receiver incorporated in the system and tuned to the same frequency.

The transmitter, piloted by a quartz crystal oscillator, is amplitude modulated by a low-frequency oscillator. This latter is controlled by a circuit tuned to a frequency between 200 and 5000 Hz. The choice of frequency of the pilot quartz crystal oscillator and that of the frequency of modulation offer a method of providing several combinations in order to personalise the stop device. The number of combinations, in the order of 300, renders the device inviolable by any other person.

The receiver built into the detector is of the superheterodyne type. Its intermediate frequency is 455 kHz. Its local oscillator is piloted by a quartz crystal oscillator whose tuning frequency, due regard being had to the intermediate frequency, corresponds to that of the transmitter. After detection, the low-frequency signal is passed to a band filter tuned to the modulation frequency of the transmitter.

In the case of a particular embodiment, the receiver antenna forms an integral part of the printed circuit carrying all circuits of the detector.

The supply system for the intrusion detector may be of any conventional type.

In accordance with a preferred embodiment the device operates on an a.c. supply. A transformer and rectifier device produces the required d.c. voltage for the electronic circuits. The detector also contains an electric accumulator to meet any possible failure in the mains supply.

A voltage regulation system regulates the voltage passed to the circuits irrespective of variations in the mains supply. Should it be necessary to operate for some considerable time on the accumulator, this regulation system can disconnect the accumulator from the device in order to obviate possible damage caused by a prolonged discharge.

At the beginning of the present description, reference was made to the difficulties encountered in hitherto known systems concerning directivity of the transmitter-receiver antenna for this type of device. A type of antenna will now be described which is very advantageously adapted to and combined with an intrusion detector according to the invention.

It is known that electromagnetic radiation is slightly attenuated by dielectric materials. In general, the materials employed in the construction of inner walls in private houses or flats may be considered as dielectric materials. In spite of a loss factor which is not inconsiderable, such materials (cavity brick, wood, plaster) are partially transparent to electromagnetic radiation. Only mid-walls of reinforced concrete containing several metal grids, or steel landing doors (fire-control or anti-theft) may be considered as screens opaque to such radiation. Consequently, the detector offers the possibility of being able to cover several rooms separated by light, mid-walls in the premises. On the other hand, it is also liable to be set off by someone appearing outside the limits of the premises if these lie within the field of radiation of the device. It is therefore absolutely necessary that the effective field of the antenna is directional whilst covering a wide angular sector in the horizontal plane.

By judicious positioning of the device, this directivity will protect the premises whilst eliminating all points where there is public access.

The radiation diagram in the vertical plane must be sufficiently narrow to ensure minimum gain of the antenna and, in the case of a floored building, to eliminate from the field of radiation the occupants of other levels.

An antenna fulfilling these conditions exactly, which is moreover compact and inexpensive to fabricate, has been described in the aforementioned British Patent Application in the name of the present inventor. This antenna is preferably produced by

photoetching on a dielectric substrate, using the printed circuit technique, an embodiment thereof being shown in Fig. 4 of the accompanying drawings. The left-hand portion of the figure shows the front of an insulating board carrying the antenna proper, whilst the right-hand portion shows part of the reverse of the same board carrying the ultra-high frequency circuits of the intrusion detector according to the invention.

It should suffice to point out that the antenna comprises two V-antennas 32 and 34, the corresponding radiators 36, 38 and 36′, 38′ of which are linked by resistances 40, 40′ respectively, connected in the vicinity of the open ends of the radiators.

This chosen solution is preferably adapted to the operating frequency of the detector because the ultra-high frequency circuits (oscillator-detector, balancer, voltage supply for the antenna) may be accommodated on the same substrate.

Thus, on the reverse side of the board, shown at the right-hand of Fig. 4, the ultra-high frequency circuits and the decoupling elements (C, L, Z_0, Z_1) described with reference to Fig. 3 will be recognised in the form of a printed circuit.

WHAT I CLAIM IS:—

1. An intrusion detector having a main unit and a warning device, the main unit comprising a transmitter, a receiver, an antenna and an amplifier for passing a warning signal to the warning device, a signal being emitted by the transmitter and after being modified by the Doppler effect created by the movement of an intruder within the field of the antenna being received by the receiver thereby to produce the warning signal, and including an inhibiting circuit connected between the said main unit and the warning device; and an auxiliary amplifier for receiving and amplifying ambient interference signals and connected to one of the inputs of said inhibiting circuit so that the inhibiting circuit disconnects the main unit from the warning device in response to a signal issuing from said auxiliary amplifier.

2. A detector as claimed in Claim 1, wherein there is further included an auxiliary receiver-antenna unit for conveying a signal to the aforesaid auxiliary amplifier only in response to a signal produced by a remote-controlled portable transmitter for neutralising the warning device, said portable transmitter and said auxiliary unit being tuned to the same frequency to synchronise the intrusion detector with the portable transmitter.

3. A detector as claimed in either preceding claim, wherein the main unit operates at a frequency in the order of 1,000 MHz to 5,000 MHz.

4. A detector as claimed in any preceding claim, wherein the main unit operates at a frequency in the order of 2000 MHz to 3000 MHz.

5. A detector as claimed in any preceding claim, wherein the antenna of the main unit is a sharply highly directional antenna having a radiation beam which is narrow in the vertical plane and broad in the horizontal plane.

6. A detector as claimed in any preceding claim, wherein the main unit comprises an ultra-high frequency oscillator operating as a homodyne detector, which oscillator serves as transmitter and also as receiver.

7. A detector as claimed in Claim 6 wherein the amplifier of the main unit is a low-frequency amplifier which amplifies the beat signals produced by the homodyne detection and the Doppler effect.

8. A detector as claimed in any preceding claim, wherein the inhibiting circuit is an electronic gate comprising an operational amplifier whose positive input is connected to the main unit amplifier, whilst its negative input is connected to the auxiliary amplifier, the gate being closed in response to a signal from said auxiliary amplifier.

9. A detector as claimed in any preceding claim and including a time switch activated by the signal issuing from the inhibiting circuit, and controlling the warning device.

10. A detector as claimed in any preceding claim, wherein the main unit antenna comprises at least two longitudinally spaced dipole antennae each formed by a pair of radiators in V formation, the end of each radiator distant from the open end of the radiator being connected to the corresponding end of the radiator of the adjacent antenna and to one of the outputs of the antenna, wherein at least two adjacent antennae have corresponding radiators connected to each other by means of a resistive load connected to the radiators in the region of their open ends.

11. A detector as claimed in Claim 10, characterised in that said antenna is formed by photoetching of a metal sheet on an insulating substrate, said antenna being com-

bined with at least certain elements of the main unit, and said elements being mounted and traced in the form of a printed circuit assembly on at least one conductive area on said insulating substrate.

12. An intrusion detector substantially as hereinbefore described with reference to the accompanying drawings.

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1450236 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

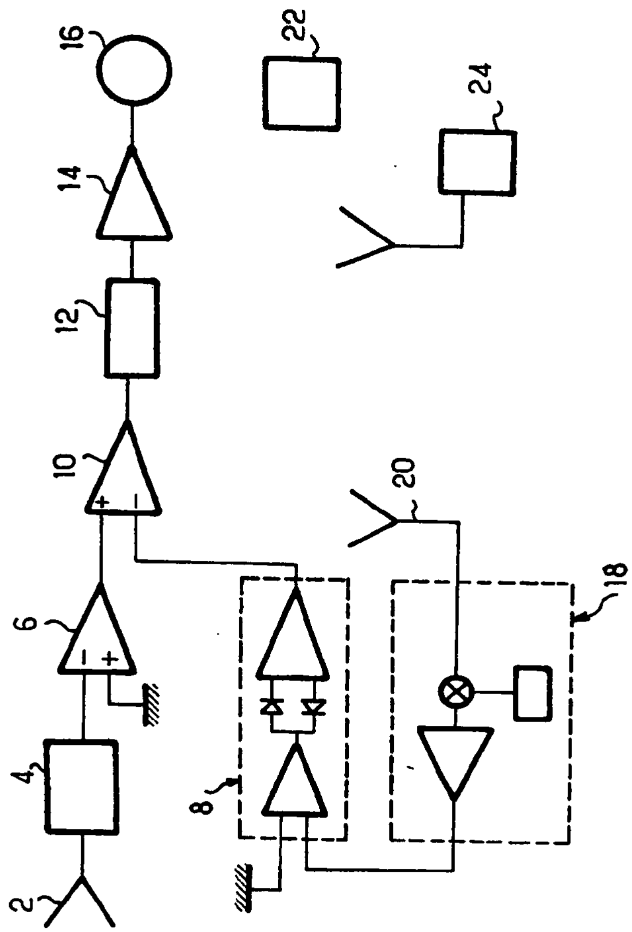


FIG. 2

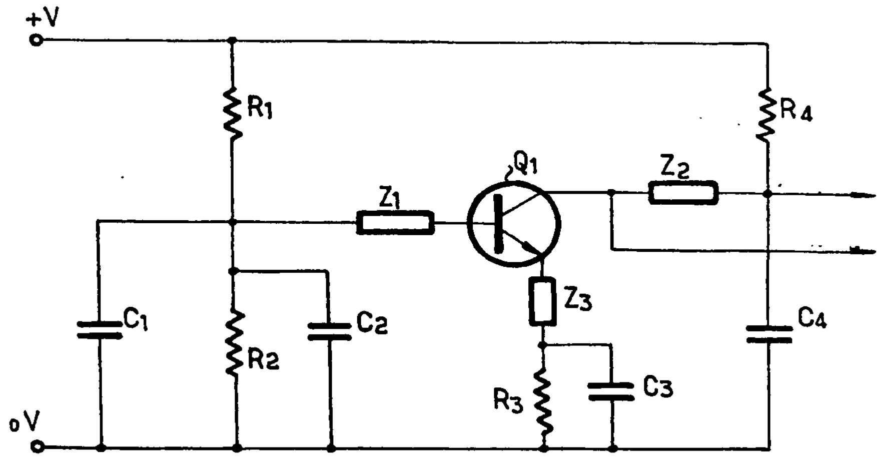
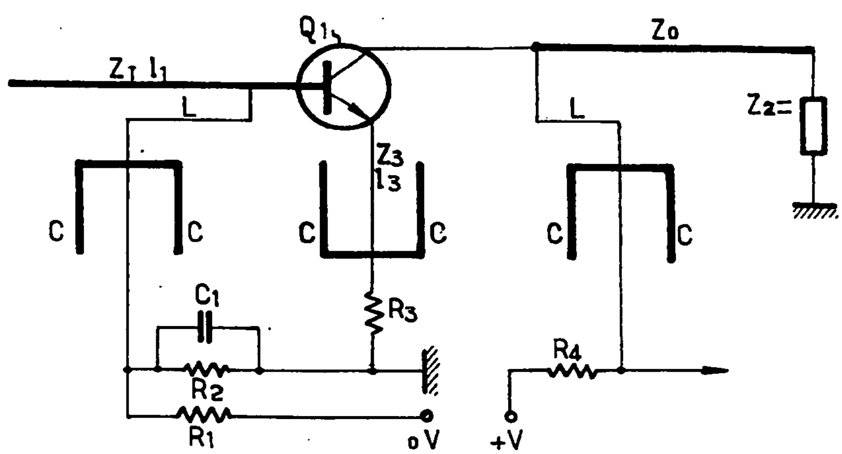

+V
R1
R4
Q1
Z2
Z1
Z3
C1
C2
C4
R2
C3
R3
oV

FIG. 3


Q1
Zo
ZI I1
L
L
Z2=
Z3
I3
C
C
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C
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C
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R3
R4
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R1
oV
+V

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Sheet 3

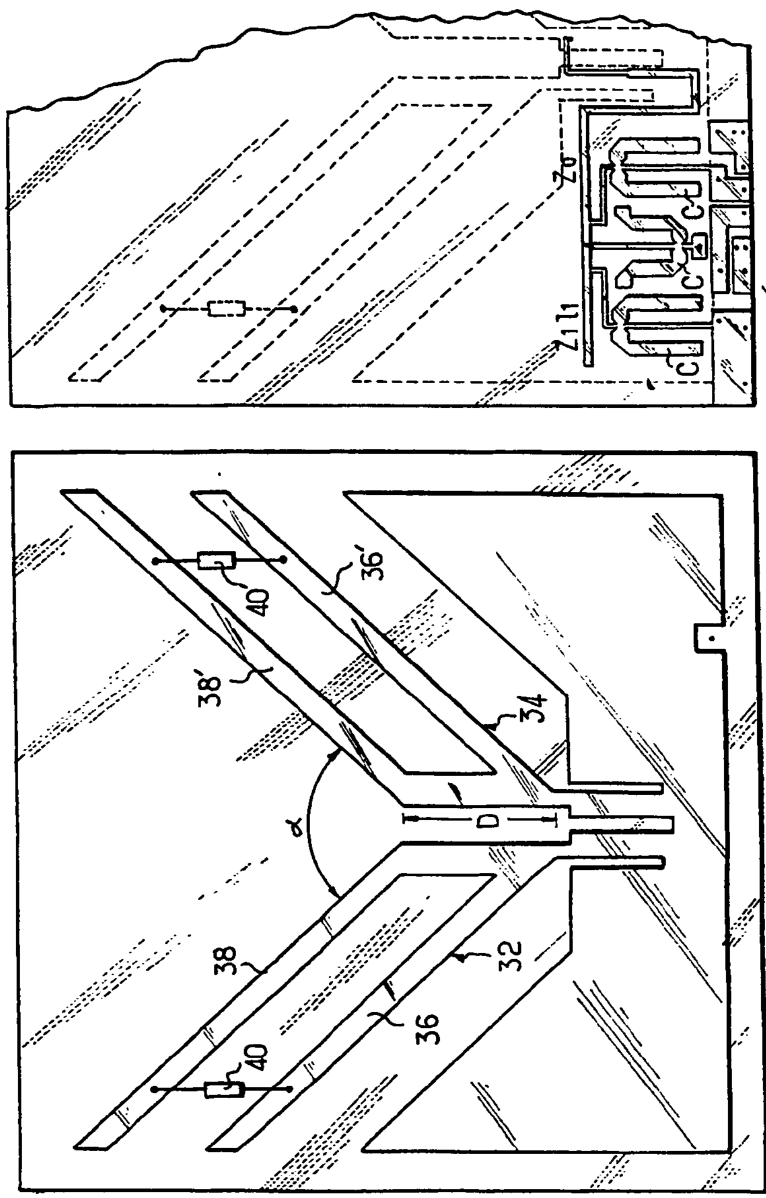

FIG.4